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Attorney Docket No.	678-241 (P8679)
First Inventor or Application Identifier	Young-Ki KIM
Title	DEVICE AND METHOD FOR PROVIDING TIME SWITCHED
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APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

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2 [X] Specification [*Total Pages* 31]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings *(if filed)*
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 14]

4 Oath or Declaration [*Total Pages*]
- a. [ ] Newly executed (original or copy)
- b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 16 completed)*
  - i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

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5 [ ] Microfiche Computer Program *(Appendix)*

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ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
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9. [ ] English Translation Document *(if applicable)*
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17. CORRESPONDENCE ADDRESS

[ ] *Customer Number or Bar Code Label* *(Insert Customer No or Attach bar code label here)* or [X] *Correspondence address below*

Name	Paul J. Farrell Dilworth & Barrese				
Address	333 Earle Ovington Boulevard				
City	Uniondale	*State*	NY	*Zip Code*	11553
Country	US	*Telephone*	(516) 228-8484	*Fax*	(516) 228-8516

Name (Print/Type)	Paul J. Farrell	*Registration No. (Attorney/Agent)*	33,494
Signature	Paul J. Farrell	*Date*	2/22/99

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DEVICE AND METHOD FOR PROVIDING TIME SWITCHED TRANSMISSION DIVERSITY IN MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to the field of communication systems, and particularly to a method and apparatus for transmitting/receiving data with a time switched transmission diversity (TSTD) function.

2. Description of the Related Art

In a mobile communication system, data transmission/reception performance can generally be enhanced by utilizing diversity techniques in a fading environment. Typically, as shown in FIG. 1 three diversity techniques are applicable to the forward link and a single diversity technique (i.e., receiver diversity) is applicable to the reverse link. Data can be received on the reverse link with receiver diversity by equipping a base station with a plurality of reception antennas. For the forward link, the three well known diversity techniques include transmission diversity, receiver diversity, and mixed diversity. In transmission diversity, a base station transmits a signal through a plurality of transmission antennas and a mobile station receives the signal through a single reception antenna to achieve the same effect as if multiple reception antennas were used. Receiver diversity is provided when the mobile station has a plurality of reception antennas, and mixed diversity is defined as a combination of the two aforementioned techniques.

Receiver diversity on the forward link, however, is problematic in that diversity gain is low because of the small terminal size which limits the distance between reception antennas. Another problem is that the use of multiple reception antennas requires a separately procured hardware configuration for receiving a forward link signal and transmitting a reverse link signal through a corresponding antenna, thereby imposing constraints on the size and cost of the terminal. In view of these problems, mobile communication systems typically employ transmission diversity exclusively on the forward link.

FIG. 2 illustrates a general block diagram of a mobile communication system employing transmission diversity on a forward link. A base station 100 and a mobile station 200 include transmitting and receiving apparatus, respectively. A baseband signal processor 103 of base station 100 converts user data for transmission on the forward link into a baseband signal. Such conversion by baseband signal processor 103 includes channel encoding, interleaving, orthogonal modulation, and PN (Pseudo Noise) spreading. A signal distributor 102 distributes the signals received from the baseband signal processor 103 into N signal streams with each stream being provided to one of N transmission antennas TXAI to TXAN. As a result, transmission diversity is achieved at the transmission end of the base station 100 through the N antennas.

The mobile station 200 has a single reception antenna RXA for receiving signals from the base station 100 from the N transmission antennas. To process the received signals, the mobile station 200 includes N demodulators 201 to 20N corresponding to each N transmission antenna. A combiner 211 combines demodulated signals received

from the demodulators 201 to 20N, and a decoder & controller 213 decodes a signal received from the combiner 211 to produce decoded user data.

In contrast, the structure of a transmitter in a non-transmission diversity (NTD) CDMA communication system is described with reference to FIG. 3. A base station 300 includes a CRC (Cyclic Redundancy Check) generator 311 for adding CRC bits to input user data in order to detect a frame error which occurs while sending the user data. A tail bit generator 313 adds tail bits indicating termination of a data frame to the data frame prior to channel encoding. Then, a channel encoder 315 encodes the data frame for error correction and an interleaver 317 interleaves the encoded data. A combiner 323 performs an exclusive-OR operation on the interleaved data with a long code sequence. This long code sequence is generated in a long code generator 319 and decimated in a decimator 321 at the same rate as that at the output terminal of the interleaver 317. A signal mapper 325 converts 0s and 1s of the encoded data received from the combiner 323 to +1s and -1s respectively, for orthogonal modulation. A serial-to-parallel (S/P) converter 327 divides the signal received from the signal mapper 325 into I channel and Q channel streams, for QPSK (Quadrature Phase Shift Keying) modulation. The I channel and Q channel streams are subject to orthogonal modulation in multipliers 329 and 331 and PN spreading in a PN spreader 333. The spread signals are filtered for pulse shaping in LPFs (Low Pass Filters) 335 and 337, loaded on a carrier by mixers 339, 341, combined with combiner 343, and finally transmitted through a transmission antenna.

The transmit signal which is output from the NTD transmitter in the base station 300 illustrated in FIG. 3 has a signal structure indicated by 511 of FIG. 5. Specifically,

FIG. 5 illustrates timing characteristics for the case of transmitter diversity and no diversity. Specifically in the case of no diversity, FIG. 5 illustrates user data output from the NTD 511 transmitter, and for the diversity case. FIG. 5 further illustrates timing characterization from an orthogonal transmission diversity (OTD) transmitter with two antennas, A & B (N=2).

FIG. 4 is a block diagram of an OTD transmitter with two transmission antennas (N=2). Improved performance of a forward link is achieved in the OTD transmitter by dividing information for one user into two or more streams and transmitting the divided data through the plurality of transmission antennas, as indicated by 513 and 515 of FIG. 5. The following description is conducted with the understanding that $[\mathbf{W}_m - \mathbf{W}_m]$ is identical to $[\mathbf{W}_m \ \overline{\mathbf{W}_m}]$.

The OTD transmitter, illustrated in FIG. 4, operates in the same manner as the NTD transmitter of FIG. 3, except for a serial-to-parallel conversion process. In the OTD structure, mapped data branches into N streams, corresponding to the number of transmission antennas in S/P converters 413, 415, and 417, and orthogonally modulated in multipliers 419, 421, 423, and 425, for maintaining mutual orthogonality between the transmission antennas.

In addition to orthogonal modulation, orthogonal codes may be further utilized to ensure mutual orthogonality among the N antennas. The orthogonal code extension is accomplished by a Hadamard matrix extension. In the case of the OTD transmitter with two transmission antennas A and B(i.e., A and B as shown in FIG. 4) the different

orthogonal codes assigned to the antennas are respectively $[\mathbf{W}_m\ \mathbf{W}_m]$ and $[\mathbf{W}_m\ -\mathbf{W}_m]$, extended from an orthogonal code $\mathbf{W}_m$ of a length 2^m used in the NTD transmitter. The purpose of orthogonal code extension is to compensate for the data rate of each of the N streams, which is 1/N of the data rate prior to serial-to-parallel conversion.

A receiver for receiving a signal from the OTD transmitter requires signal demodulators for demodulating user data, a pilot demodulator for providing timing and phase information to be provided to the signal demodulates, and a parallel-to-serial (P/S) converter for converting M signal demodulator outputs to a serial signal stream.

A pilot channel is used by the base station to provide timing and phase information to a mobile station. The mobile station first activates the pilot demodulator to acquire necessary timing and phase information and demodulates user data based on the acquired information. For an OTD transmitter, each transmission antenna should be assigned a unique pilot channel.

In a receiver for use with a conventional OTD transmitter of FIG. 4, the pilot demodulator subjects a received signal to PN despreading and orthogonal demodulation and integrates the resulting signal for one cycle in order to demodulate a pilot channel from the received signal. A time estimator and a phase estimator in the pilot demodulator estimate timing and phase values from the integrated value.

A signal demodulator of the receiver performs PN despreading on a user data signal based on timing information received from the pilot demodulator. A phase error

which occurs during transmission is compensated for by multiplying the phase information by an integrated value. The integrated value is obtained by integrating an orthogonally modulated signal for one cycle. The phase-compensated integrator output is converted to a probability value by a soft decision block and fed through the P/S converter to a deinterleaver.

Despite improved reception performance as compared to the NTD system, the conventional OTD mobile communication system has certain limitations. First, given that a terminal should be equipped with a number of pilot demodulators and signal demodulators corresponding to the number of transmission antennas of a base station, this results in an increase in the complexity, cost, and power consumption of a receiver.

Another drawback associated with a conventional OTD system is that the length of an orthogonal code used is increased by N times from that of an NTD case, for N transmission antennas. As a result, the integration interval is extended, thereby degrading reception performance in a frequency error-susceptible channel environment.

A further limitation is that the number of available transmission antennas is restricted to be a power of 2, namely 2^n which imposes constraints concerning a number of applications involving antenna arrays. There exists a need, therefore, for a diversity scheme which overcomes the limitations of the prior art.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a time switched transmission diversity (TSTD) apparatus and method for distributing a signal of a base station to a plurality of antennas via time switching.

Another object of the present invention is to provide a receiver for receiving a signal from a TSTD transmitter.

A further object of the present invention is to provide a TSTD communication apparatus and method in a mobile communication system, in which the length of an orthogonal code remains the same as that required in a conventional mobile communication system.

Still another object of the present invention is to provide a receiver and a receiving method in a TSTD mobile communication system, in which a single signal demodulator is utilized irrespective of the number of transmission antennas employed to achieve transmission diversity.

A still further object of the present invention is to provide a transmitter and a transmitting method in a TSTD mobile communication system, where the number of transmission antennas can be easily increased.

According to one aspect of the present invention, the above objects are achieved

by providing a time diversity transmitting apparatus in a base station of a mobile communication system. The transmitting apparatus includes a plurality (N) of transmission antennas with a corresponding number of radio frequency transmitters connected therewith for outputting signals on a forward link. The transmitter further includes a controller for generating a switch controlling signal in a non-overlapped time cycle, an orthogonal modulator for modulating a transmit signal by an orthogonal code, a spreader for spreading the output of the orthogonal modulator, and a switch connected to an output terminal of the spreader, for connecting the output of the spreader to a corresponding transmitter based on the switch controlling signal.

According to another aspect of the present invention, there is provided a receiving device in a mobile station of a mobile communication system. The receiving device has a pilot channel receiver for detecting a pilot channel signal from an input forward link signal and generating estimated phase and time values, a controller for generating a selection control signal based on cycle information and switching pattern information, in synchronization of a reference time to a base station, a selector for selectively outputting the estimated phase and time values received from the pilot channel receiver based on the selection control signal, and a traffic channel receiver for detecting a traffic channel signal at the selected estimated time position and correcting a phase error of the detected traffic channel signal based on the estimated phase value, for signal decoding.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and advantages of the present invention will become more

apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 illustrates diversity techniques on forward and reverse links in a mobile communication system;

FIG. 2 is a block diagram of a transmission diversity-based apparatus on a forward link in a mobile communication system according to the present invention;

FIG. 3 is a block diagram of an NTD transmitter in a mobile communication system according to the prior art;

FIG. 4 is a block diagram of a conventional OTD transmitter in a mobile communication system according to the prior art;

FIG. 5 illustrates data structures transmitted from the NTD and OTD transmitters shown in FIGS. 3 and 4, respectively;

FIG. 6 is a block diagram of a TSTD transmitter in a mobile communication system according to an embodiment of the present invention;

FIG. 7 is a block diagram of a controller shown in FIG. 6;

FIG. 8 illustrates timing characteristics of data transmitted in a periodic pattern from the TSTD transmitter of FIG. 6;

FIG. 9 illustrates timing characteristics of data transmitted in a random pattern from the TSTD transmitter of FIG. 6;

FIG. 10 illustrates timing characteristics of data for plural users synchronously transmitted from the TSTD transmitter of FIG. 6;

FIG. 11 illustrates timing characteristics of data for a plurality of users asynchronously transmitted from the TSTD transmitter of FIG. 6;

FIG. 12 describes transmission antenna extensibility in a TSTD transmitter of the

mobile communication system according to the embodiment of the present invention;

FIG. 13 is a block diagram of an embodiment of a receiving device for receiving data from a TSTD transmitting device in the mobile communication system according to the present invention; and

FIG. 14 is a block diagram of another embodiment of a receiving device for receiving data from a TSTD transmitting device in the mobile communication system according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A mobile communication system according to an embodiment of the present invention distributes user data to a plurality of transmission antennas by time switching to achieve transmission diversity. The system further demodulates the time diversity-based signal in a single signal demodulator. The features of time diversity according to the present invention may be summarized as:

(1) A single signal demodulator is provided for demodulating user data regardless of the number N of transmission antennas utilized. That is, only one orthogonal code is available per user. As such, the single demodulator simplifies the receiver design, accommodates low power dissipation and results in low terminal costs;

(2) The length of an orthogonal code is the same as that of an orthogonal code used in an NTD device, regardless of the number N of transmission antennas. This implies that there is no increase of an integration interval for providing time diversity; and

(3) The number of available transmission antennas is not restricted to be a power

of 2, 2^n but is limitlessly extensible, thereby imposing no constraints on other applications.

Prior to describing the structure and operation of a transmitter in a base station and a receiver in a terminal according to the embodiment of the present invention, it is to be noted that the method of time diversity in accordance with the present invention is applied to the forward link in a mobile communication system of the present invention.

FIG. 6 is a block diagram of a TSTD transmitter with two (N=2) transmission antennas in a base station according to the present invention.

Referring to FIG. 6, a signal mapper 611 receives a signal resulting from combining encoded user data with a long code whereby the long code changes the level of the received signal by converting 0s and 1s to +1s and -1s, respectively. An S/P converter 613, coupled to the signal mapper output, converts a serial signal received from the signal mapper 611 to an odd-numbered signal and an even-numbered signal. A multiplier 615, coupled to the even output of the S/P converter, multiplies the even-numbered signal by an orthogonal code $\mathbf{W}_m$. A multiplier 617, coupled to the odd output of the S/P converter, multiplies the odd-numbered signal by an orthogonal code $\mathbf{W}_m$. These multipliers 615 and 617 function to subject a user signal to orthogonal modulation (i.e., orthogonal spreading) by multiplication. The orthogonal code can be a Walsh code. A PN spreader 619 multiplies the orthogonally modulated signals received from the multipliers 615 and 617 by corresponding PN sequences PN_I and PN_Q, for PN spreading (or PN masking) of a signal to be transmitted.

A controller 600 generates a switch controlling signal for distributing a transmit signal to a plurality of antennas in the TSTD transmitter of the present invention. The controller 600 synchronizes to a GPS (Global Positioning System) signal in a synchronous mode and a switching cycle is an integer multiple of the orthogonal code length. In addition, a look-up table for storing switching information with respect to a hopping pattern may be provided to the controller 600 in an alternate embodiment whereby time switching is performed in a specific pattern.

A switch 621 switches in response to a switch controlling signal output by the controller 600, and has a common terminal coupled to output terminals of the PN spreader 619 from which I channel and Q channel spread signals are transmitted, a first output terminal coupled to LPFs 623 and 625, and a second output terminal coupled to LPFs 627 and 629. As previously stated, the switch 621 switches based on a switch controlling signal received from the controller 600 and selectively outputs the spread signals received from the PN spreader 619 to the low pass filters LPFs 623 and 625 or to the LPFs 627 and 629.

The LPFs 623 and 625 low-pass-filter the I channel and Q channel PN spread signals received from the switch 621. Multipliers 631 and 633 multiply outputs of the LPFs 623 and 625 by carriers, for frequency up conversion. An adder 641 adds signals received from the multipliers 631 and 633 and sends the resulting signal to a transmission antenna A.

The LPFs 627 and 629 low-pass-filter the I channel and Q channel PN spread

signals received from the switch 621. Multipliers 635 and 637 multiply outputs of the LPFs 627 and 629 by carriers, for frequency up conversion. An adder 643 adds signals received from the multipliers 631 and 633 and sends the resulting signal to a transmission antenna B.

The structure shown in FIG. 6 can be adapted as a forward channel transmitter in the TSTD base station. Forward channel transmitters include a pilot channel transmitter, a sync channel transmitter, a control channel transmitter, and a traffic channel transmitter. Considering that a pilot channel provides time synchronization for transmission of data on a forward link, the pilot channel transmitter can be configured to be an OTD structure, while the other channel transmitters can use the TSTD structure shown in FIG. 6.

FIG. 7 is a block diagram of the controller 600 shown in FIG. 6. Referring to FIG. 7, a reference cycle register 711 stores a reference cycle signal received from an upper-level processor. The reference cycle signal acts as a time switching cycle in a channel transmitter. A clock counter 713 receives clock pulses from a base station system, counts the clock pulses in a reference cycle unit, and generates read pulses. A look-up table 715 stores switching pattern information received from the upper-level processor and outputs corresponding switching information in response to the read pulses received from the clock counter 713. A control signal generator 717 generates a switch controlling signal for distributing a PN spread signal to a plurality of transmission antennas according to the pattern information read from the look-up table 715.

By way of example, the controller 600 of FIG. 7 functions to connect a baseband

output to N antennas for transmission in successive time intervals in a TSTD base station transmitter. The reference cycle register 711 stores a time switching cycle for a channel so that each channel can be uniquely time-switched. That is, designating a different reference cycle signal for each channel in the reference cycle register 711 results in transmission of each channel at a unique switching cycle rate. The value stored in the reference cycle register 711 is designated separately for each channel in the upper-level processor prior to transmission of the channel, and can be changed during data transmission under a separately determined control.

The clock pulses input to the clock counter 713 are provided from the base station system, synchronized to a reference time in the base station, and have a clock cycle proportional to an orthogonal code length. The clock counter 713 counts the clock pulses, compares the counted value with the value stored in the reference cycle register 711, and sends read pulses to the look-up table 715 at the time point when the values are equal.

The look-up table 715 is a memory for storing a time switching pattern of data transmitted through the N transmission antennas. A different switching pattern can be assigned to each channel, or channels can share the same switching pattern. The switching pattern stored in the look-up table 715 is to be transmitted from the base station to the terminal to allow the terminal to demodulate data based on the switching pattern.

The control signal generator 717 analyzes the switching pattern read from the look-up table 715 and controls signal paths to the N transmission antennas. That is, only one selected transmission antenna is enabled and the other transmission antennas are

disabled.

In summary, the controller 600 counts input clock pulses, compares the counted value with a reference cycle value, and generates a read signal corresponding to a switching pattern stored in the look-up table 715 if the values are equal. The switching pattern information is used to select a transmission antenna in a subsequent step. The thus-obtained switching information is changed to an enable/disable signal for each transmission path.

FIG. 8 illustrates a comparison between signal characteristics transmitted from a conventional NTD transmitter and the TSTD transmitter of the present invention shown in FIG. 6. In FIG. 8, reference numeral 811illustrates an output timing of an NTD transmitter. Reference numerals 813 and 815 illustrate the timings of signals respectively transmitted through transmission antennas A and B in the TSTD transmitter. It is apparent that only one antenna is active (i.e., A or B) at any point in time in accordance with the teachings of the present invention.

In operation, the TSTD transmitter uses one orthogonal code per user, as compared to an OTD transmitter requiring as many orthogonal codes as there are transmission antennas. Further, the OTD transmitter operates in the same manner as the NTD transmitter, up to PN spreading. Then, for an TSTD transmitter the PN spread data is switched to each transmission antenna in a cycle equal to an integer multiple of an orthogonal code length, either in a periodic pattern for sequential data transmission to the N transmission antennas or in a random pattern. The time switching pattern used is

determined by the output of the look-up table 715 in the controller 600, and a time switching cycle is determined by a reference cycle value stored in the reference cycle register 711.

FIG. 9 illustrates, by way of example, a random transmission pattern from two antennas (i.e., A and B), while FIG. 8 illustrates a periodic pattern for antennas A and B. With reference to FIG. 9, look-up table 715 would be loaded, for example, with a switching pattern requiring that data should be connected to the transmission antenna A for two consecutive iterations and then to transmission antenna B once in the TSTD transmitter of FIG. 6. In response, the controller 600 control the switch 621 to connect the output of the PN spreader 619 to the LPFs 623 and 625 for two consecutive switching cycles and to the LPFs 627 and 629 for one subsequent switching cycle. As a result, the timings of signals output from the transmission antennas A and B are shown as indicated by 913 and 915 of FIG. 9, respectively. Random time switching patterns can additionally offer the data scrambling effect.

FIG. 10 is a timing diagram of user data under the following conditions: N=2, two users, and synchronous time switching in the TSTD transmitter of a base station.

FIG. 11 is a timing diagram of user data under the following condition: N=2, two users, and asynchronous time switching in the TSTD transmitter. Synchronous time switching is distinguishable from asynchronous time switching depending upon whether the same or different time switching schemes are applied to all terminals for a base station.

FIG. 12 is a timing diagram comparing user data transmitted from a TSTD transmitter and the OTD transmitter. In FIG. 12, N=3 and a periodic pattern is selected. As illustrated, the TSTD transmitter exhibits time diversity with three transmission antennas. This result is not obtainable in the OTD case.

Two types of receiving devices may be used for a terminal corresponding to a TSTD transmitting device. In one type, OTD is applied to a pilot channel and TSTD to all other channels. In the second type, TSTD is applied to all channels including the pilot channel and user data channels.

FIGS. 13 and 14 are block diagrams of the two types of receiving devices. Because the pilot channel is a common channel for synchronizing the PN code between the base station and the terminal. Either OTD or TSTD with a predetermined cycle and pattern can be rendered to transmission of the pilot channel.

FIG. 13 is a block diagram of a receiving device for receiving a baseband signal from a transmitting device having two transmission antennas, a TSTD traffic channel transmitter, and an OTD pilot channel transmitter. Referring to FIG. 13, the receiver includes a number of pilot channel receivers equal to the number of transmission antennas of the transmitting device. Specifically, two pilot channel receivers 1310 and 1320 are provided corresponding to transmission antennas A and B. The pilot channel receivers should preferably use orthogonal codes extended in length, proportional to the number of the transmission antennas.

In the pilot channel receiver 1310, a PN despreader 1311 multiplies an input signal by a PN sequence, for PN despreading. A multiplier 1313 orthogonally demodulates the signal received from the PN despreader 1311 by multiplying the received signal by the same orthogonal code $[W_m\ W_m]$ as the one used in the pilot channel transmitter. An integrator 1315 integrates a signal received from the multiplier 1311 for a time T and sums the integrated values. A phase estimator 1317 analyzes a signal received from the integrator 1315 and outputs an estimated phase value 0 of the pilot signal received through the transmission antenna A. A time estimator 1319 analyzes the signal received from the integrator 1315 and outputs an estimated time value 0 as the transmission time of the pilot signal received through the transmission antenna A. The time estimator 1319 outputs an estimated time value 1 as the transmission time of the pilot signal received through the transmission antenna B.

In the pilot channel receiver 1320, a PN despreader 1321 multiplies the input signal by a PN sequence, for PN despreading. A multiplier 1323 orthogonally demodulates the signal received from the PN despreader 1321 by multiplying the received signal by the same orthogonal code $[W_m\ \overline{W_m}\ ]$ as the other used in the pilot channel transmitter. An integrator 1325 integrates a signal received from the multiplier 1321 for a time T and sums the integrated values. A phase estimator 1327 analyses a signal received from the integrator 1325 and outputs an estimated phase value 1 of the pilot signal received through the transmission antenna B. A time estimator 1329 analyses the signal received from the integrator 1325 and outputs an estimated time value 1 as the transmission time of the pilot signal received through the transmission antenna B.

A controller 1341 synchronizes to a reference time of the base station and generates a control signal for selecting the outputs of the pilot channel receivers 1310 and 1320 in a time switching cycle unit. A selector 1343 selectively outputs the estimated phase and time values received from the pilot channel receivers 1310 and 1320 on the basis of the control signal of the controller 1341.

In a traffic channel receiver 1330, a PN despreader 1331 multiplies an input signal at a transmission time position indicated by the time signal received from the selector 1343 by a PN sequence. That is, the PN despreader 1331 despreads the input signal by the PN code at the estimated switching time position. A multiplier 1333 multiplies the orthogonal code $[W_n]$ used in the traffic channel transmitter by a signal received from the PN despreader 1331. An integrator 1335 integrates a signal received from the multiplier 1333 for the time T and sums the integrated values. A phase sign converter 1345 changes the sign of the phase value received from the selector 1343. A multiplier 1337 multiplies the output of the integrator 1335 by the output of the phase sign converter 1345, to synchronize the phase of the input signal. A level decision block 1339 detects the level of a signal received from the multiplier 1337 and changes the signal level to a gray level. The signal output from the level decision block 1339 is fed to a decoder in the receiver.

The receiving device shown in FIG. 13 includes pilot channel demodulators equal to the number of transmission antennas employed, N. In the present example, N=Z. These pilot channel receivers are similarly configured as the OTD receivers and operate in the same manner. A single traffic channel receiver 1330 is all that is required because even though modulation of user data is distributed to N transmission antennas, each of the

n data paths use the same orthogonal code.

The estimated time and phase information for the N transmission antennas is selectively provided from the pilot channel receivers 1310 and 1320 to the traffic channel receiver 1330 by the selector 1343 based on the clock signal of the controller 1341 synchronized to the base station. That is, the terminal obtains switching cycle and pattern information from the base station during a call set-up.

The controller 1341 obtains the information pertaining to the current selected switching scheme by demodulating a sync channel based on time and phase information pilot obtained from a demodulated pilot channel and analyzing information loaded on the demodulated sync channel. Upon detection of the switching scheme for TSTD in a receiving device, the terminal can be synchronized to the base station for time switching.

The traffic channel receiver 1330 subjects a user data signal to PN despreading using the estimated time value selectively received from the selector 1343 and orthogonally demodulates the PN spread signal. Then, it integrates the orthogonal modulation signal for one cycle, and multiplies the integrated value by a value obtained from converting the sign of phase information selected by the selector 1343, to thereby compensate for a phase error which occurs during data transmission. The phase-compensated integrator output is subjected to soft decision and converted to a probability value in the level decision block 1339 and fed through a P/S converter (not shown) to a deinterleaver (not shown).

FIG. 14 is a block diagram of another embodiment of a receiving device for receiving a signal from a transmitting device having a TSTD structure for all channel transmitters. The receiving device in this embodiment includes a single pilot channel receiver since a pilot channel signal is also time switched for transmission.

In a pilot channel receiver 1410, a PN despreader 1411 multiplies an input signal by a PN sequence, for PN despreading. A multiplier 1413 orthogonally demodulates the signal received from the PN despreader 1411 by multiplying the received signal by the same orthogonal code $\mathbf{W}_m$ as that used in a corresponding pilot channel transmitter. An integrator 1415 integrates a signal received from the multiplier 1411 for a time T and sums the integrated values. A phase estimator 1417 analyses a signal received from the integrator 1415 and outputs an estimated phase value of a pilot channel signal received through transmission antennas. A time estimator 1419 analyzes the signal received from the integrator 1415 and outputs an estimated time value as the transmission time of the pilot channel signal received through the transmission antennas.

A controller 1441 synchronizes to a reference time of the base station and generates a control signal for selecting the outputs of the pilot channel receiver 1410 in a time switching cycle unit. A selector 1443 selectively outputs the estimated phase and time values received from the pilot channel receiver 1410 on the basis of the control signal of the controller 1441.

In a traffic channel receiver 1420, a PN despreader 1421 multiplies an input signal at a time position indicated by the time signal received from the selector 1343 by a PN

sequence. That is, the PN despreader 1421 despreads the input signal by the PN code at the estimated switching time position. A multiplier 1423 multiplies the orthogonal code $[W_n]$ used in a corresponding traffic channel transmitter by a signal received from the PN despreader 1421. An integrator 1425 integrates a signal received from the multiplier 1423 for the time T and sums the integrated values. A phase sign converter 1431 changes the sign of the phase value received from the selector 1443. A multiplier 1427 multiplies the output of the integrator 1425 by the output of the phase sign converter 1431, to synchronize the phase of the input signal. A level decision block 1429 detects the level of a signal received from the multiplier 1427 and changes the signal level to a gray level. The signal output from the level decision block 1429 is fed to a decoder in the receiver.

The receiving device shown in FIG. 14 shows an example where TSTD is executed on a pilot channel as well as traffic channels. Since one orthogonal code is used for the pilot channel, which differs from the receiving device of FIG. 13, all necessary timings and estimated phases can be generated by the use of the single pilot channel receiver 1410 with implementation of the same time switching technique as that for the traffic channel receiver 1420.

In summary, TSTD on a forward link in a mobile communication system offers the following advantages:

(1) only one traffic channel receiver is needed for demodulating user data regardless of the number N of transmission antennas, since one orthogonal code is available per user, which enables simplification of a receiver, low power dissipation and low terminal costs;

(2) The length of an orthogonal code is unchanged by virtue of using the orthogonal code in an NTD device. Therefore, there is no increase of an integration interval for providing time diversity and no degradation of the reception performance possibly caused by a channel environment such as a frequency error;

(3) The number of available transmission antennas is not limited, thereby imposing no constraints on other applications; and

(4) A scrambling effect can be added to improvement in reception performance by applying different switching techniques to users in a base station.

While the present invention has been described in detail with reference to the specific embodiments, they are mere exemplary applications. Thus, it is to be clearly understood that many variations can be made by anyone skilled in the art within the scope and spirit of the present invention.

CLAIMS

WHAT IS CLAIMED IS:

1. A transmitting apparatus for a wireless communication system, comprising:

a spreader for spreading a transmit signal;

at least two antennas;

a plurality of RF transmitters operatively coupled to the antennas for converting an input signal to an RF signal and outputting the RF signal through the antennas; and

a time switching transmission controller coupled between the spreader and the RF transmitters, for mutually exclusively switching an output of the spreader between the plurality of transmitters in non-overlapping time intervals, thereby providing transmission time diversity.

2. The transmitting apparatus of claim 1, wherein the time switching transmission controller comprises:

a controller having pre-stored switching patterns, for generating a switch controlling signal based on one of the pre-stored switching patterns, said controlling signal being generated at said fixed non-overlapping predetermined time interval; and

a switch connected between an output terminal of the spreader and an input terminal each of said plurality of RF transmitters, for switching the output of the spreader to a corresponding RF transmitter based on the switch controlling signal.

3. The transmitting apparatus of claim 2, wherein the controller comprises:

a reference cycle storage for storing a reference switching cycle value;

a counter for counting clock pulses of a base station and outputting a counted value based on the reference switching cycle value;

a memory for storing a plurality of switching patterns and outputting one of said plurality of switching patterns based on the counted value; and

a control signal generator for generating the switch controlling signal according to the switching pattern selected from the memory.

4. The transmitting apparatus of claim 3, wherein the memory stores at least one of a sequential switching pattern, a random switching pattern, a switching pattern with a uniform switching cycle, and a switching pattern with a variable switching cycle, and the control signal generator generates the switch controlling signal with length equal to an integer multiple of an orthogonal code length.

5. A transmitter device in a mobile communication system, comprising:

i) a plurality of dedicated channel transmitters, each channel transmitter having at least two antennas, a plurality of RF transmitters operatively coupled to the antennas for converting an input signal to an RF signal and outputting the RF signal through the antennas,

ii) a dedicated channel spreader for spreading a dedicated channel signal,

iii) a time switching transmission controller connected between the dedicated channel spreader and the RF transmitters, for switching the output of the

spreader between the RF transmitters in non-overlapping time intervals; and

iv) a pilot channel transmitter having a symbol distributor for distributing pilot channel symbols to the antennas, a plurality of orthogonal spreaders for spreading the distributed symbols by different orthogonal codes, and a plurality of PN spreaders for spreading the orthogonally spread signals by PN codes and outputting the PN spread signals to the RF transmitters.

6. The transmitter of claim 5, wherein the time switching transmission controller comprises:

a controller having switching patterns, for generating a switch controlling signal based on a switching pattern at a predetermined time; and

a switch connected between an output terminal of the spreader and input terminals of the RF transmitters, for switching the output of the spreader to a corresponding RF transmitter based on the switch controlling signal.

7. The transmitting device of claim 6, wherein the controller comprises:

a reference cycle storage for storing a reference switching cycle value;

a counter for counting clock pulses of a base station and outputting the counted value based on the reference switching cycle value;

a memory for storing switching patterns and outputting a switching pattern based on the counted value; and

a control signal generator for generating the switch controlling signal according to the switching pattern received from the memory.

8. The transmitting device of claim 7, wherein the memory stores at least one of a sequential switching pattern, a random switching pattern, a switching pattern with a uniform switching cycle, and a switching pattern with a variable switching cycle, and the control signal generator generates the switch controlling signal as long as an integer multiple of an orthogonal code length.

9. A channel receiving device in a mobile communication system, comprising:

a pilot channel receiver for despreading a pilot channel signal from an input signal and estimating phase and time values;

a reception controller for selecting the estimated phase and time values according to the switching cycle and pattern of a TSTD (time switching transmission diversity) signal from a base station through at least two antennas at the base station; and

a traffic channel receiver for receiving the TSTD signal from the base station, detecting a channel signal based on the estimated time value, and correcting a phase error of the detected channel signal based on the estimated phase value, for demodulation.

10. The channel receiving device of claim 9, wherein the traffic channel receiver comprises:

a PN despreader for PN-despreading the input signal at a time position in accordance with the estimated time value;

an orthogonal despreader for depreading the PN-despread signal by a corresponding channel orthogonal code; and

a demodulator for correcting a phase error of the orthogonal despread signal based on the estimated phase value.

11. A channel receiving device in a mobile communication system, comprising:

a plurality of pilot channel receivers for receiving Orthogonal Transmission Diversity (OTD) pilot signals through at least two antennas, and estimating phase and time values of corresponding pilot channel signals by despreading the pilot channel signals;

a reception controller for selecting estimated phase and time values according to the switching cycle and pattern of TSTD signals received from a base station through at least two antennas; and

a traffic channel receiver for receiving the TSTD signals, detecting a channel signal based on the estimated time values, and correcting a phase error of the detected channel signal based on the estimated phase values, for demodulation.

12. The channel receiving device of claim 11, wherein the traffic channel receiver comprises:

a PN despreader for PN-despreading the input signal at a time position in accordance with the estimated time value;

an orthogonal despreader for depreading the PN-despread signal by a corresponding channel orthogonal code; and

a demodulator for correcting a phase error of the orthogonal despread signal based on the estimated phase value.

13. A channel signal transmitting method in a mobile communication system, comprising the steps of:

spreading a transmit signal by a corresponding orthogonal signal for a dedicated

channel;

spreading the orthogonally spread signal by a PN code; and

switchedly supplying the PN-spread signal to a corresponding antenna selected from at least two antennas in non-overlapping time intervals thereby generating a TSTD signal according to a predetermined switching pattern.

14. The transmitting method of claim 13, wherein the TSTD signal generating step comprises the steps of:

generating a switch controlling signal based on the switching pattern at a predetermined time; and

switching the PN-spread signal to a corresponding transmission antenna based on the switch controlling signal.

15. The transmitting method of claim 14, wherein the switch controlling step comprises the steps of:

generating a reference switching cycle signal;

counting clock pulses of a base station and outputting the counted value at the time point when the reference switching cycle value is generated;

outputting a switching pattern based on the counted value; and

generating the switch controlling signal according to the switching pattern.

16. The transmitting method of claim 15, wherein the switching pattern is at least one of a sequential switching pattern, a random switching pattern, a switching pattern with a uniform switching cycle, and a switching pattern with a variable switching

cycle, and the switch controlling signal is an integer multiple of an orthogonal code length.

17. A channel signal receiving method in a mobile communication system, comprising the steps of:

(1) despreading a pilot channel signal from an input signal and estimating phase and time values;

(2) selecting the estimated phase and time values according to the switching cycle and pattern of a TSTD signal received from a base station through at least two antennas; and

(3) detecting an TSTD dedicated channel signal based on the estimated time value, and correcting a phase error of the detected TSTD signal based on the estimated phase value, for demodulation.

18. The channel signal receiving method of claim 17, wherein step (3) further comprises the steps of:

PN-despreading the input signal at a time position indicated by the estimated time value;

despreading the PN-despread signal by a corresponding dedicated channel orthogonal code; and

correcting a phase error of the orthogonal despread signal based on the estimated phase value.

ABSTRACT OF THE DISCLOSURE

The invention provides a method and apparatus for transmitting signalling information to a receiver using a plurality of transmission antennas in a time switching configuration. The apparatus includes a controller for generating a switch controlling signal in a non-overlapped time cycle for selecting one of the plurality of transmission antennas to output a transmission signal in a fixed, non-overlapped time interval. The invention further provides for a receiving device for detecting a pilot channel signal from an input forward link signal and generating estimated phase and time values for detecting a traffic channel signal at the selected estimated time position and correcting a phase error of the detected traffic channel signal based on the estimated phase value, for signal decoding.

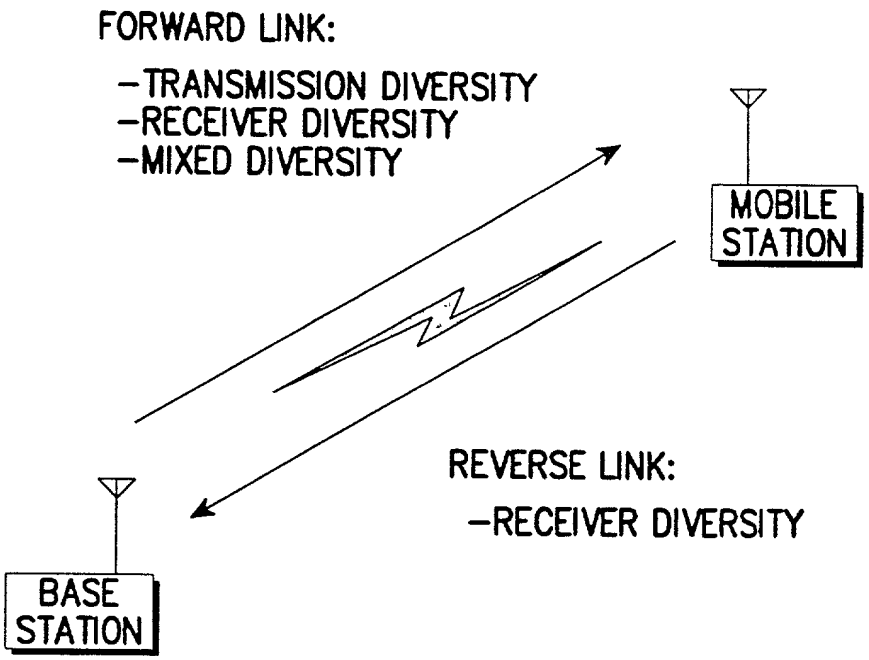
FORWARD LINK:
-TRANSMISSION DIVERSITY
-RECEIVER DIVERSITY
-MIXED DIVERSITY
MOBILE STATION
REVERSE LINK:
-RECEIVER DIVERSITY
BASE STATION

FIG. 1

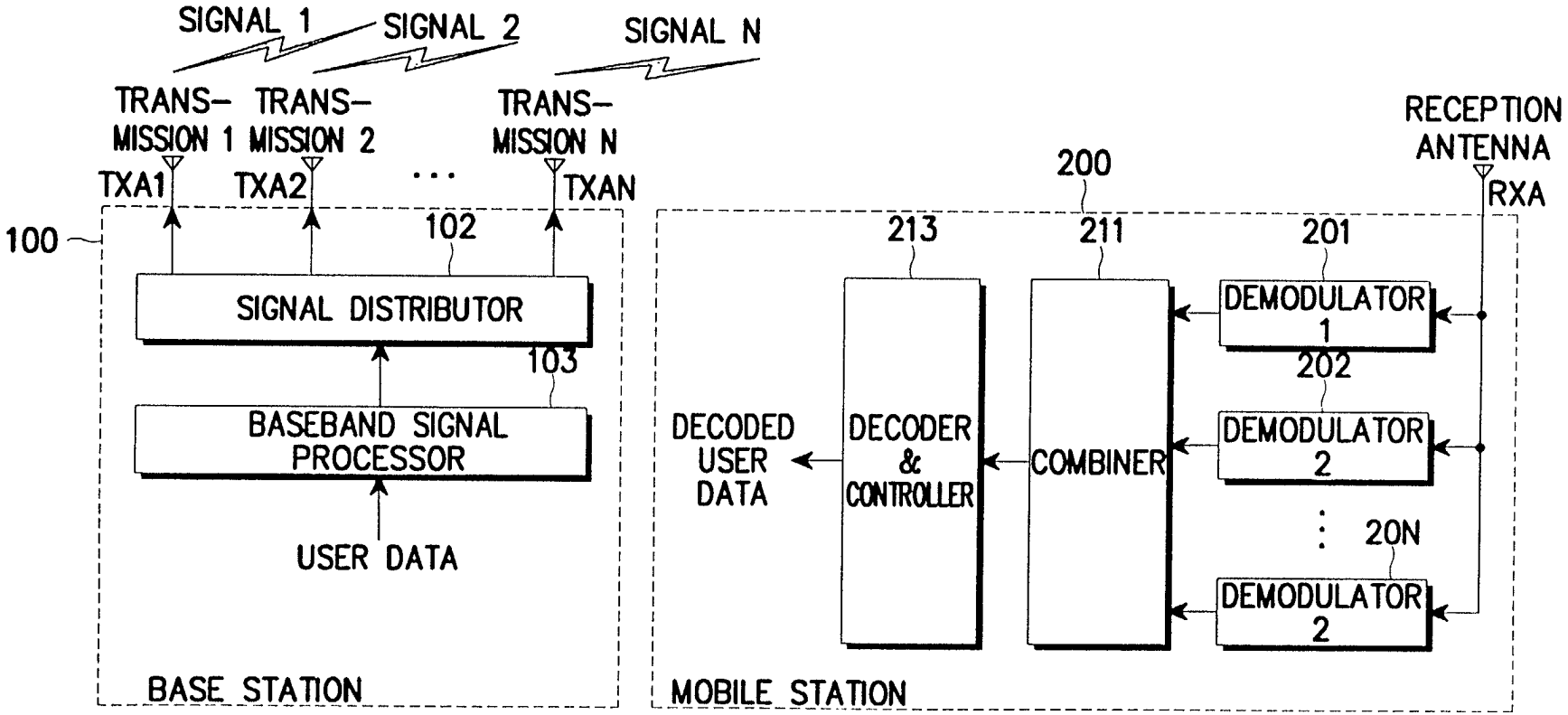
SIGNAL 1
SIGNAL 2
SIGNAL N
TRANS-MISSION 1
TRANS-MISSION 2
TRANS-MISSION N
TXA1
TXA2
TXAN
100
102
SIGNAL DISTRIBUTOR
103
BASEBAND SIGNAL PROCESSOR
USER DATA
BASE STATION
200
RECEPTION ANTENNA
RXA
213
211
201
DEMODULATOR 1
202
DEMODULATOR 2
20N
DEMODULATOR 2
DECODED USER DATA
DECODER & CONTROLLER
COMBINER
MOBILE STATION

FIG. 2

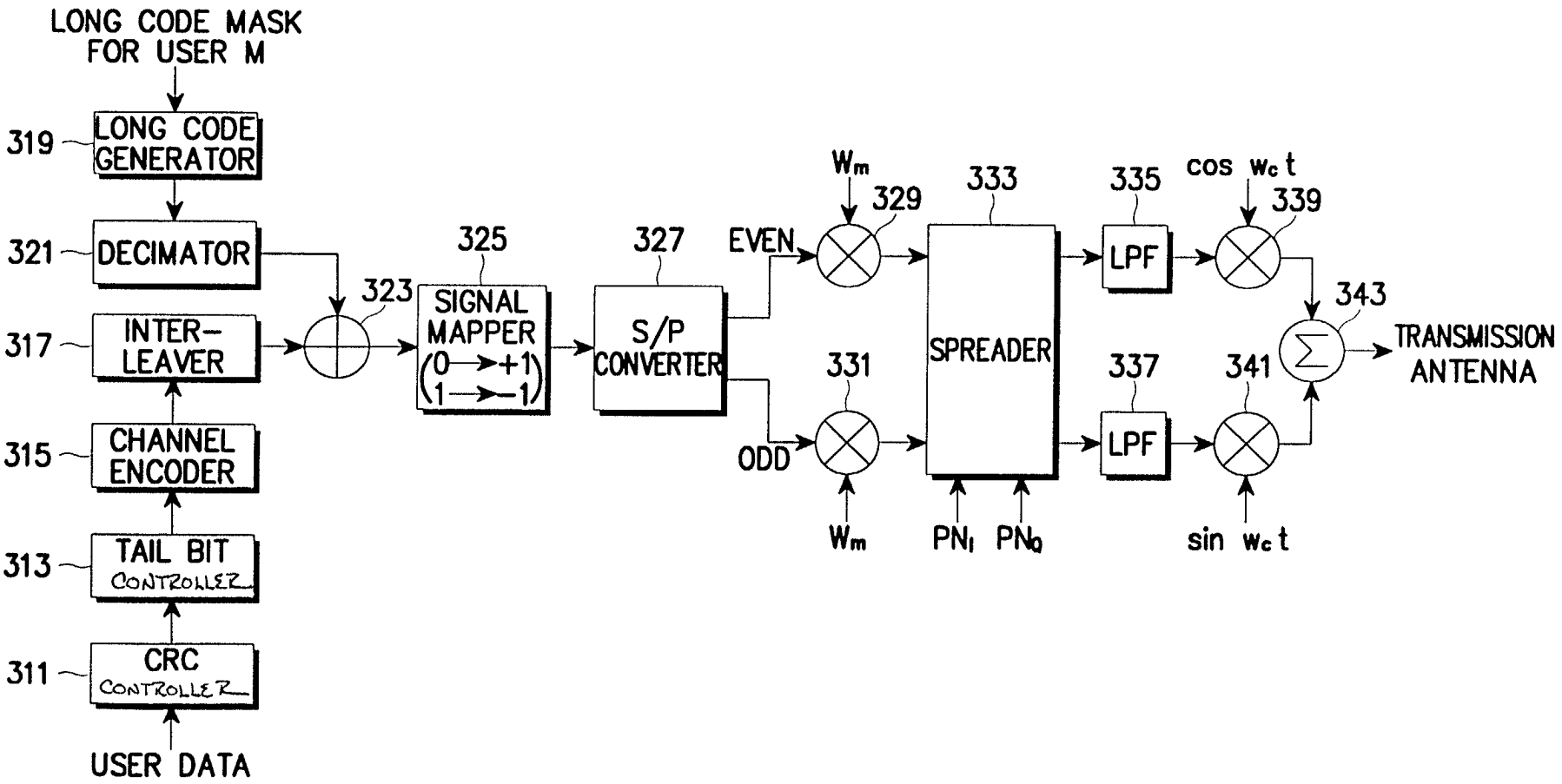
LONG CODE MASK FOR USER M
319
LONG CODE GENERATOR
321
DECIMATOR
317
INTER-LEAVER
315
CHANNEL ENCODER
313
TAIL BIT CONTROLLER
311
CRC CONTROLLER
USER DATA
323
325
SIGNAL MAPPER (0→+1) (1→−1)
327
S/P CONVERTER
EVEN
ODD
Wm
329
331
333
SPREADER
PNI
PNQ
335
LPF
337
LPF
cos wc t
339
sin wc t
341
343
TRANSMISSION ANTENNA

FIG. 3

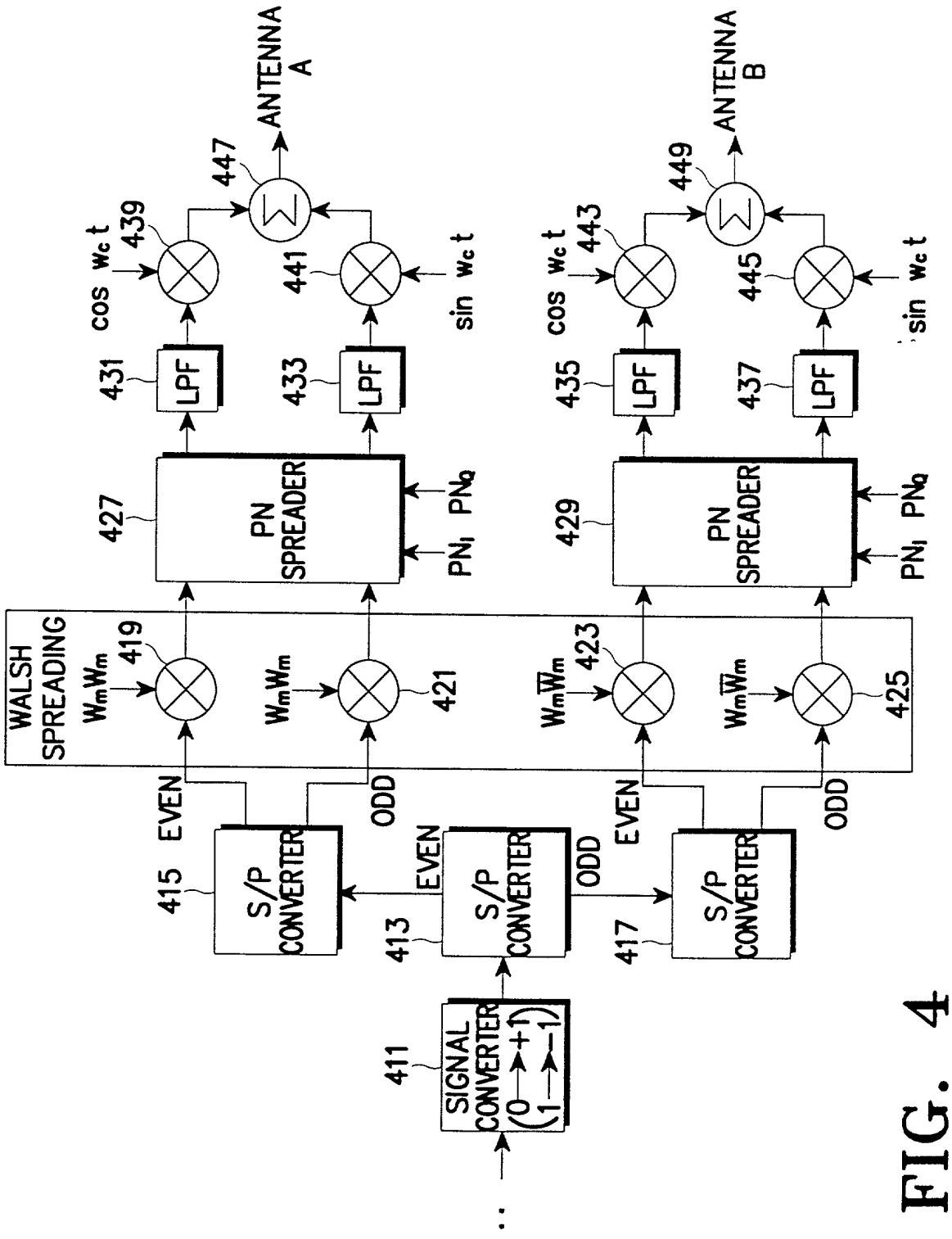
411
SIGNAL CONVERTER
(0→+1)
(1→−1)
413
S/P CONVERTER
415
S/P CONVERTER
417
S/P CONVERTER
EVEN
ODD
EVEN
ODD
WALSH SPREADING
419
421
423
425
427
PN SPREADER
429
PN SPREADER
PN_I PN_Q
431
LPF
433
LPF
435
LPF
437
LPF
cos w_c t
sin w_c t
439
441
443
445
447
449
ANTENNA A
ANTENNA B

FIG. 4

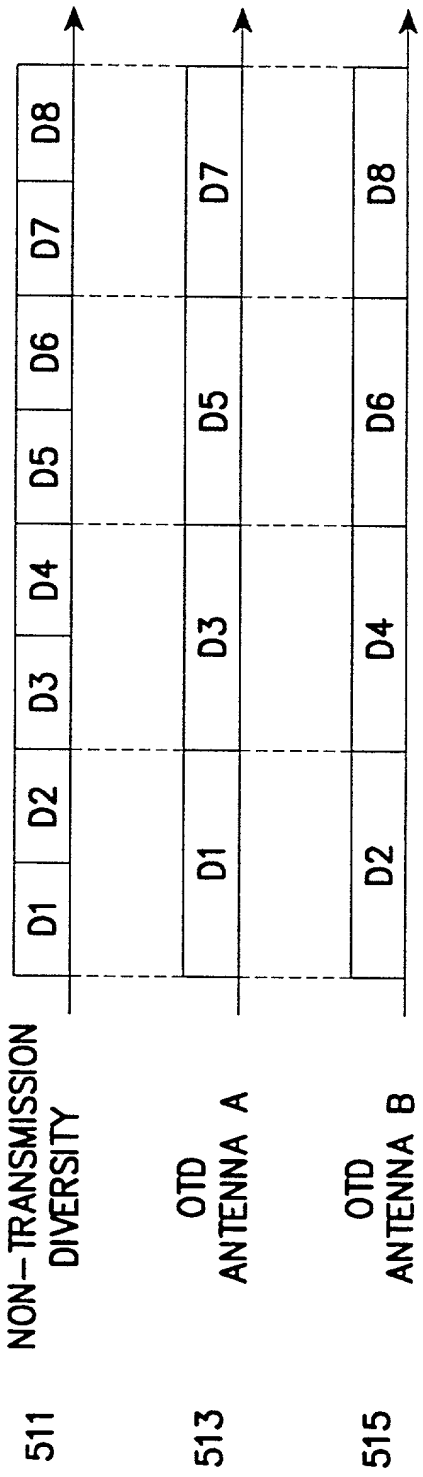
511
NON-TRANSMISSION DIVERSITY
D1
D2
D3
D4
D5
D6
D7
D8
513
OTD ANTENNA A
D1
D3
D5
D7
515
OTD ANTENNA B
D2
D4
D6
D8

FIG. 5

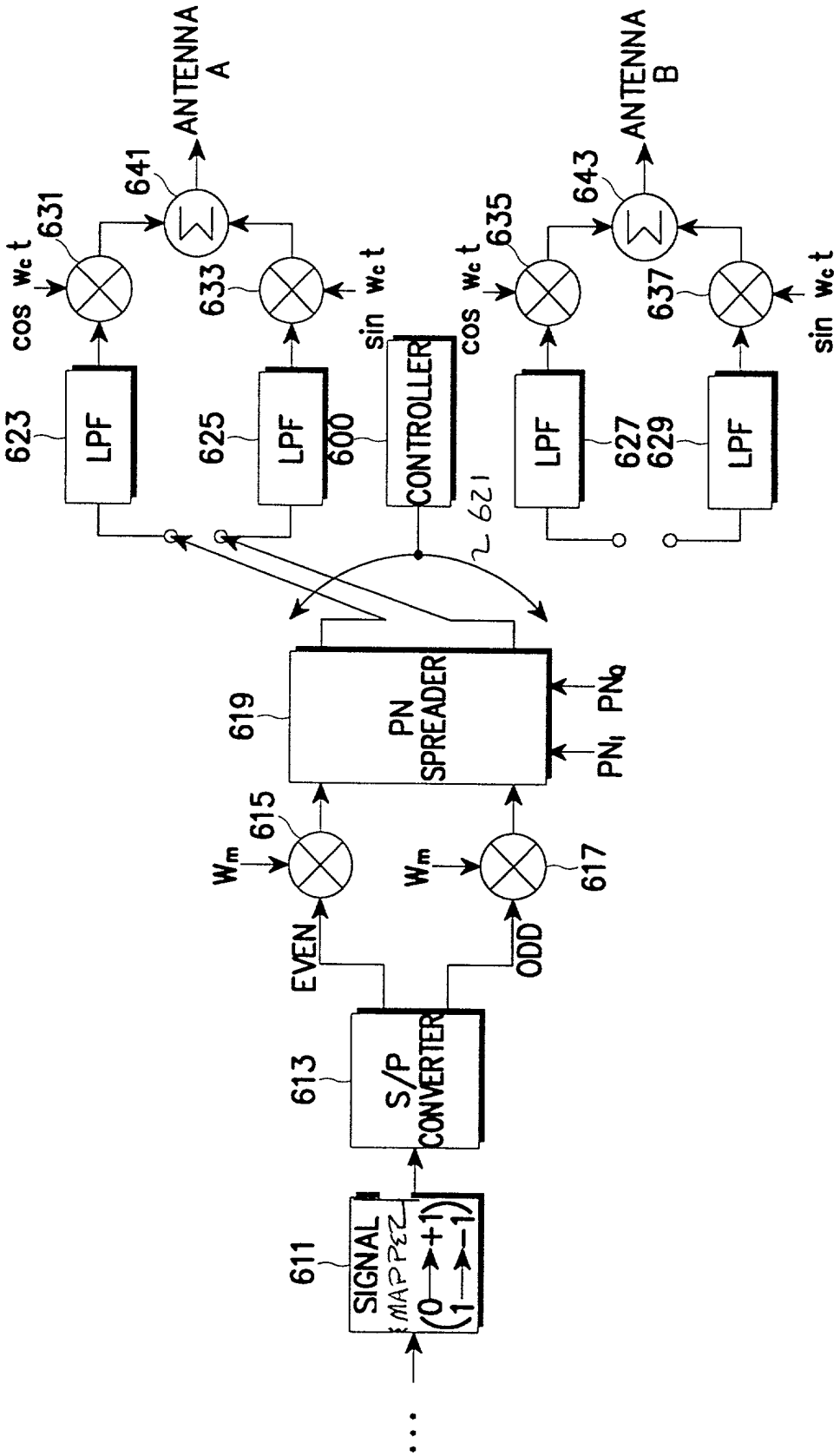
611
SIGNAL MAPPER (0→+1) (1→-1)
613
S/P CONVERTER
EVEN
ODD
615
617
W_m
619
PN SPREADER
PN_I PN_Q
600
CONTROLLER
621
623
625
627
629
LPF
631
633
635
637
641
643
cos $w_c t$
sin $w_c t$
ANTENNA A
ANTENNA B

FIG. 6

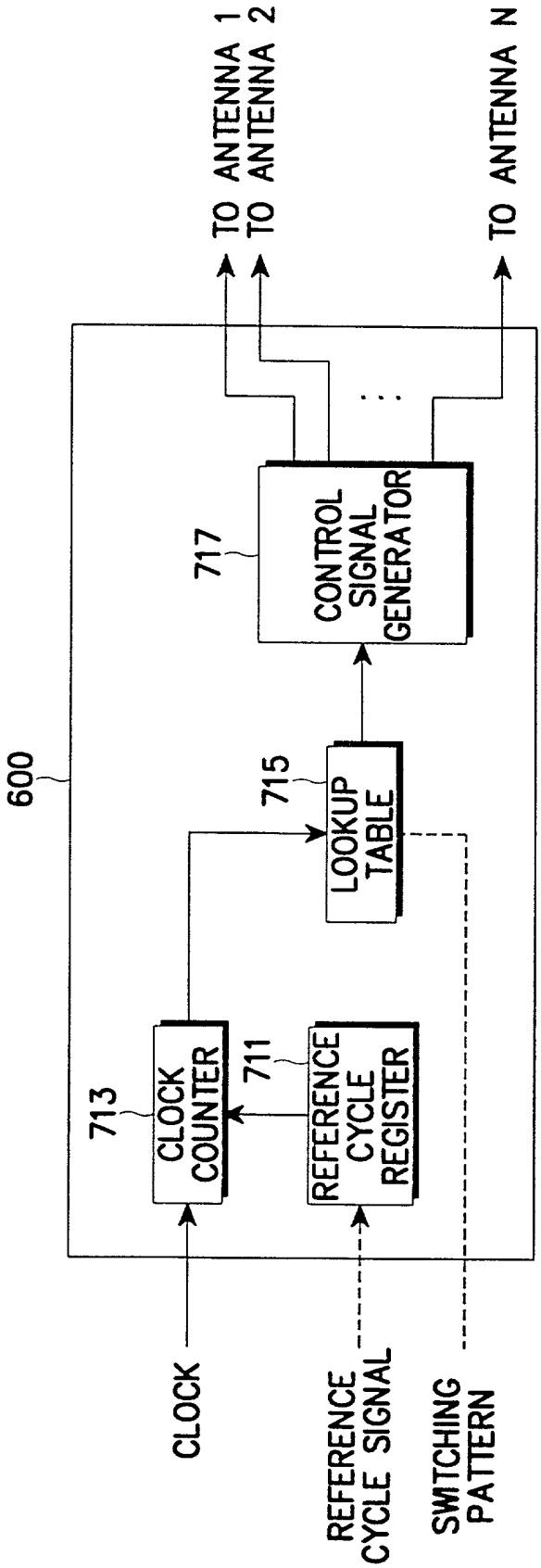
600
CLOCK
REFERENCE CYCLE SIGNAL
SWITCHING PATTERN
713
CLOCK COUNTER
711
REFERENCE CYCLE REGISTER
715
LOOKUP TABLE
717
CONTROL SIGNAL GENERATOR
TO ANTENNA 1
TO ANTENNA 2
TO ANTENNA N

FIG. 7

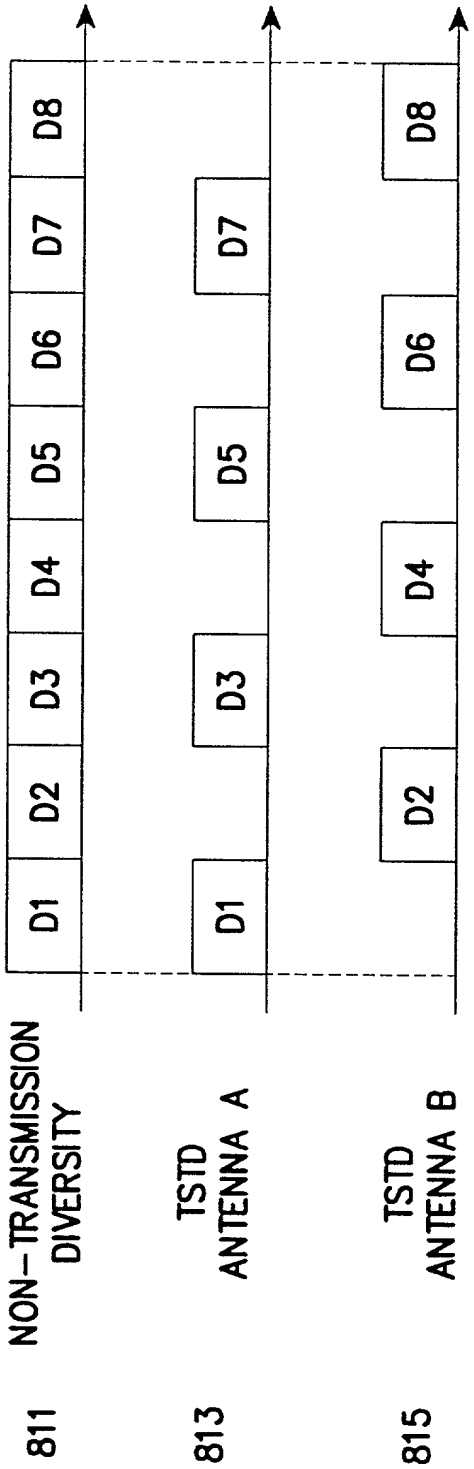
D1
D2
D3
D4
D5
D6
D7
D8
NON-TRANSMISSION DIVERSITY
811
TSTD ANTENNA A
813
TSTD ANTENNA B
815

FIG. 8

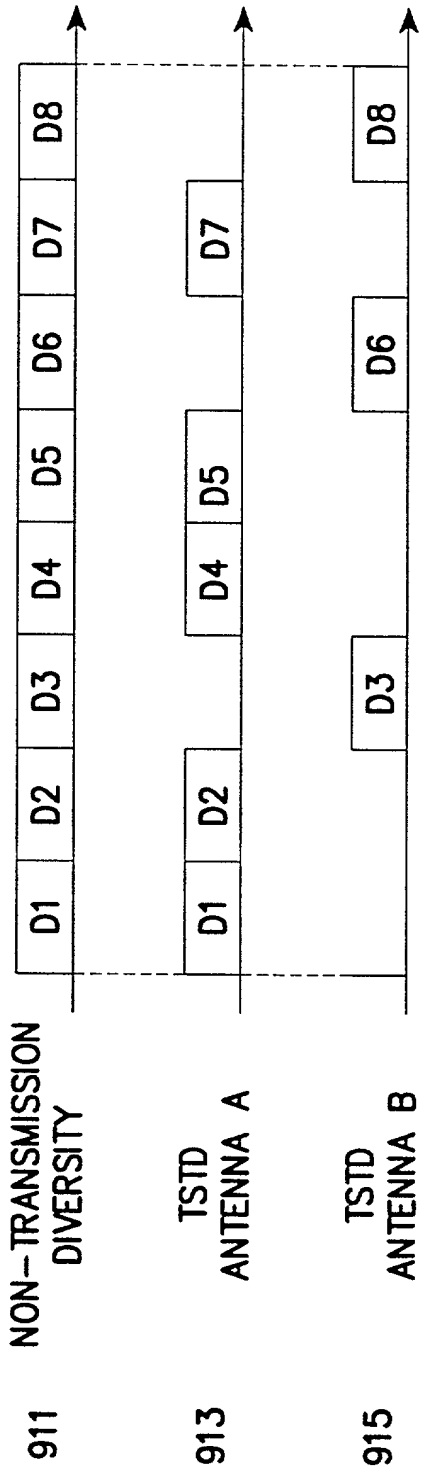
911
NON-TRANSMISSION DIVERSITY
D1
D2
D3
D4
D5
D6
D7
D8
913
TSTD ANTENNA A
D1
D2
D4
D5
D7
915
TSTD ANTENNA B
D3
D6
D8

FIG. 9

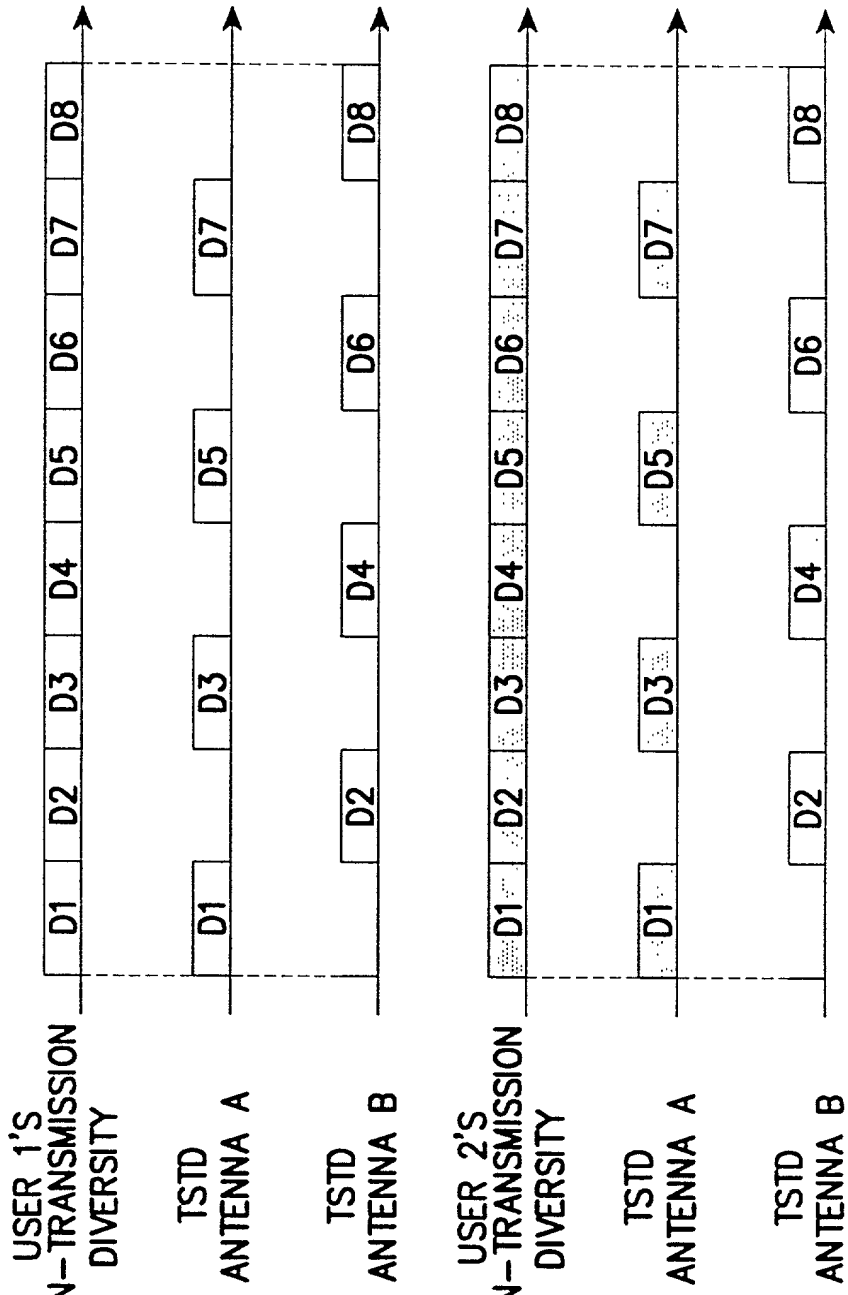
1011
USER 1'S NON-TRANSMISSION DIVERSITY
D1
D2
D3
D4
D5
D6
D7
D8
1013
TSTD ANTENNA A
D1
D3
D5
D7
1015
TSTD ANTENNA B
D2
D4
D6
D8
1021
USER 2'S NON-TRANSMISSION DIVERSITY
D1
D2
D3
D4
D5
D6
D7
D8
1023
TSTD ANTENNA A
D1
D3
D5
D7
1025
TSTD ANTENNA B
D2
D4
D6
D8

FIG. 10

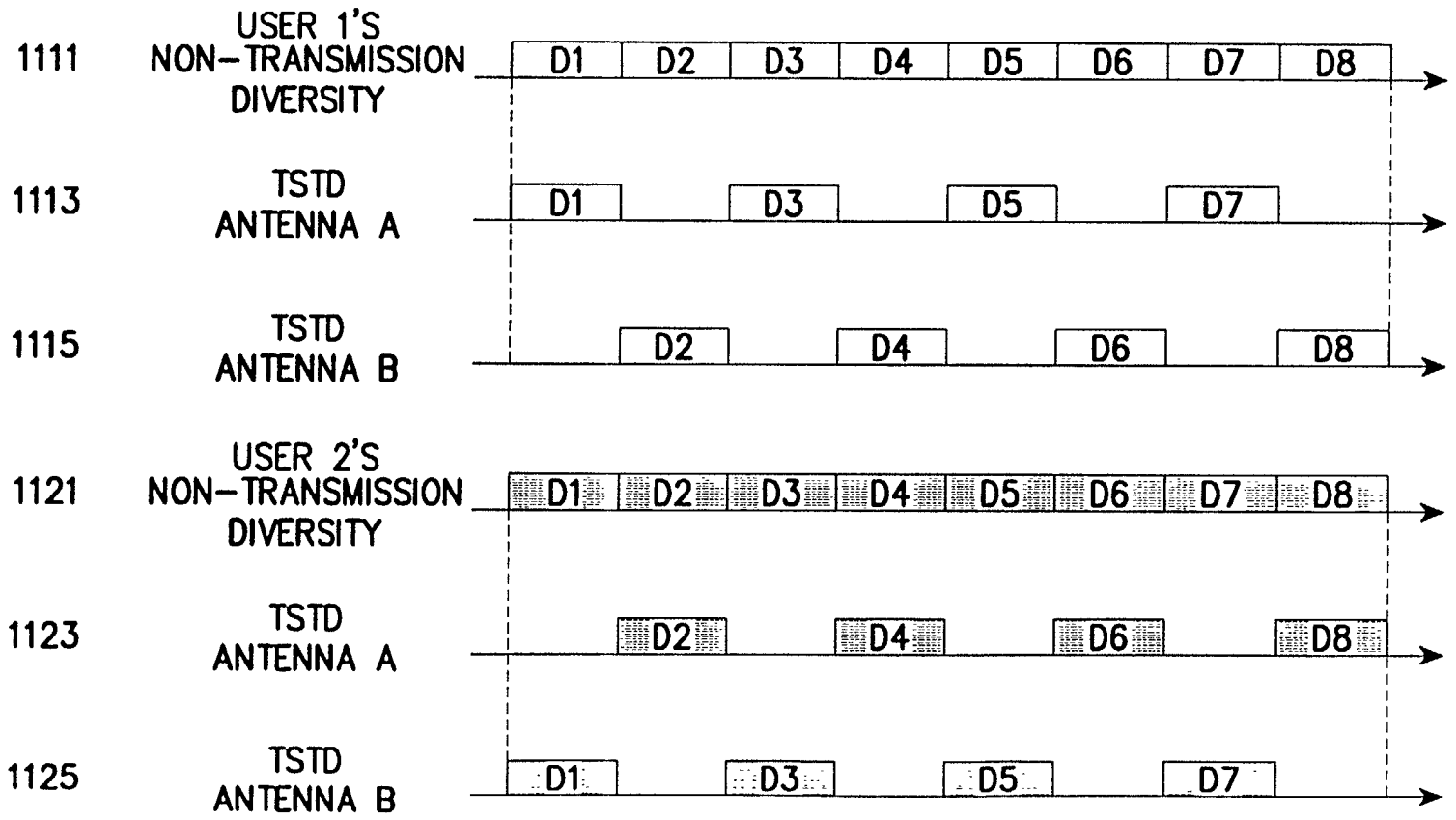
1111
USER 1'S NON-TRANSMISSION DIVERSITY
D1 D2 D3 D4 D5 D6 D7 D8
1113
TSTD ANTENNA A
D1 D3 D5 D7
1115
TSTD ANTENNA B
D2 D4 D6 D8
1121
USER 2'S NON-TRANSMISSION DIVERSITY
D1 D2 D3 D4 D5 D6 D7 D8
1123
TSTD ANTENNA A
D2 D4 D6 D8
1125
TSTD ANTENNA B
D1 D3 D5 D7

FIG. 11

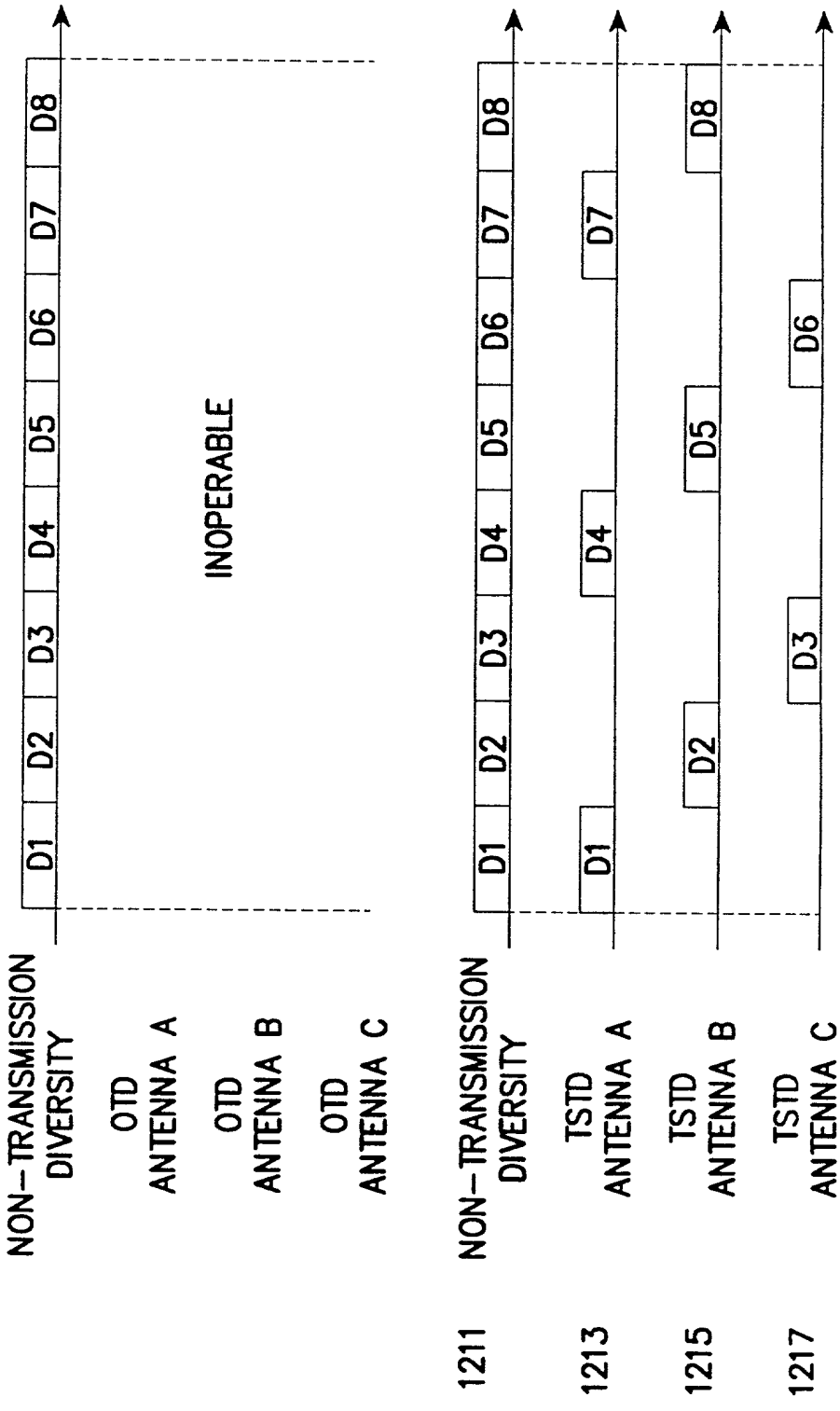
NON-TRANSMISSION DIVERSITY
OTD ANTENNA A
OTD ANTENNA B
OTD ANTENNA C
INOPERABLE
D1
D2
D3
D4
D5
D6
D7
D8
1211
NON-TRANSMISSION DIVERSITY
1213
TSTD ANTENNA A
1215
TSTD ANTENNA B
1217
TSTD ANTENNA C

FIG. 12

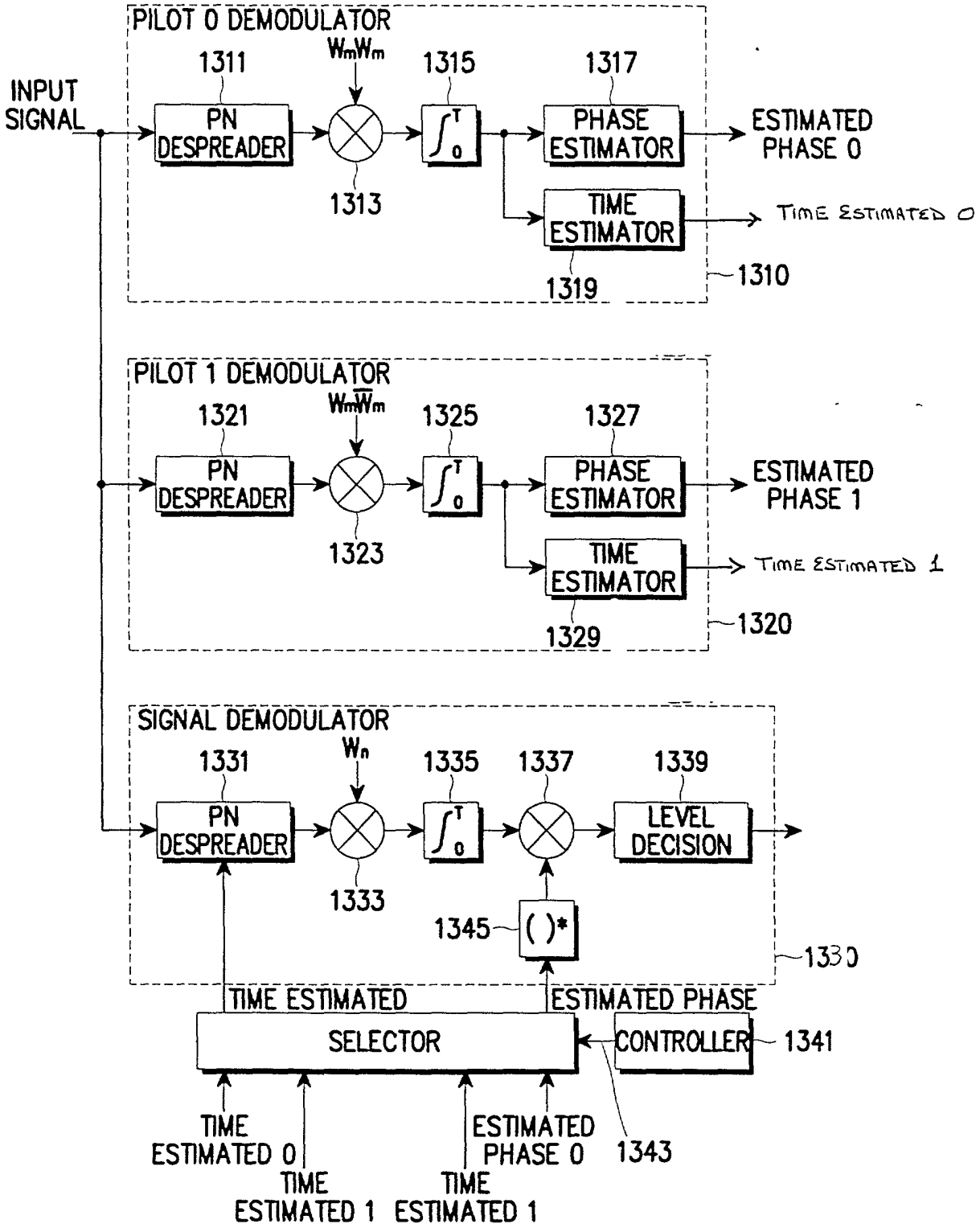
PILOT 0 DEMODULATOR
INPUT SIGNAL
1311
PN DESPREADER
W_mW_m
1313
1315
$\int_0^T$
1317
PHASE ESTIMATOR
ESTIMATED PHASE 0
TIME ESTIMATOR
TIME ESTIMATED 0
1319
1310
PILOT 1 DEMODULATOR
1321
PN DESPREADER
$W_m\overline{W}_m$
1323
1325
$\int_0^T$
1327
PHASE ESTIMATOR
ESTIMATED PHASE 1
TIME ESTIMATOR
TIME ESTIMATED 1
1329
1320
SIGNAL DEMODULATOR
1331
PN DESPREADER
W_n
1333
1335
$\int_0^T$
1337
1339
LEVEL DECISION
1345
( )*
1330
TIME ESTIMATED
ESTIMATED PHASE
SELECTOR
CONTROLLER
1341
1343
TIME ESTIMATED 0
TIME ESTIMATED 1
TIME ESTIMATED 1
ESTIMATED PHASE 0

FIG. 13

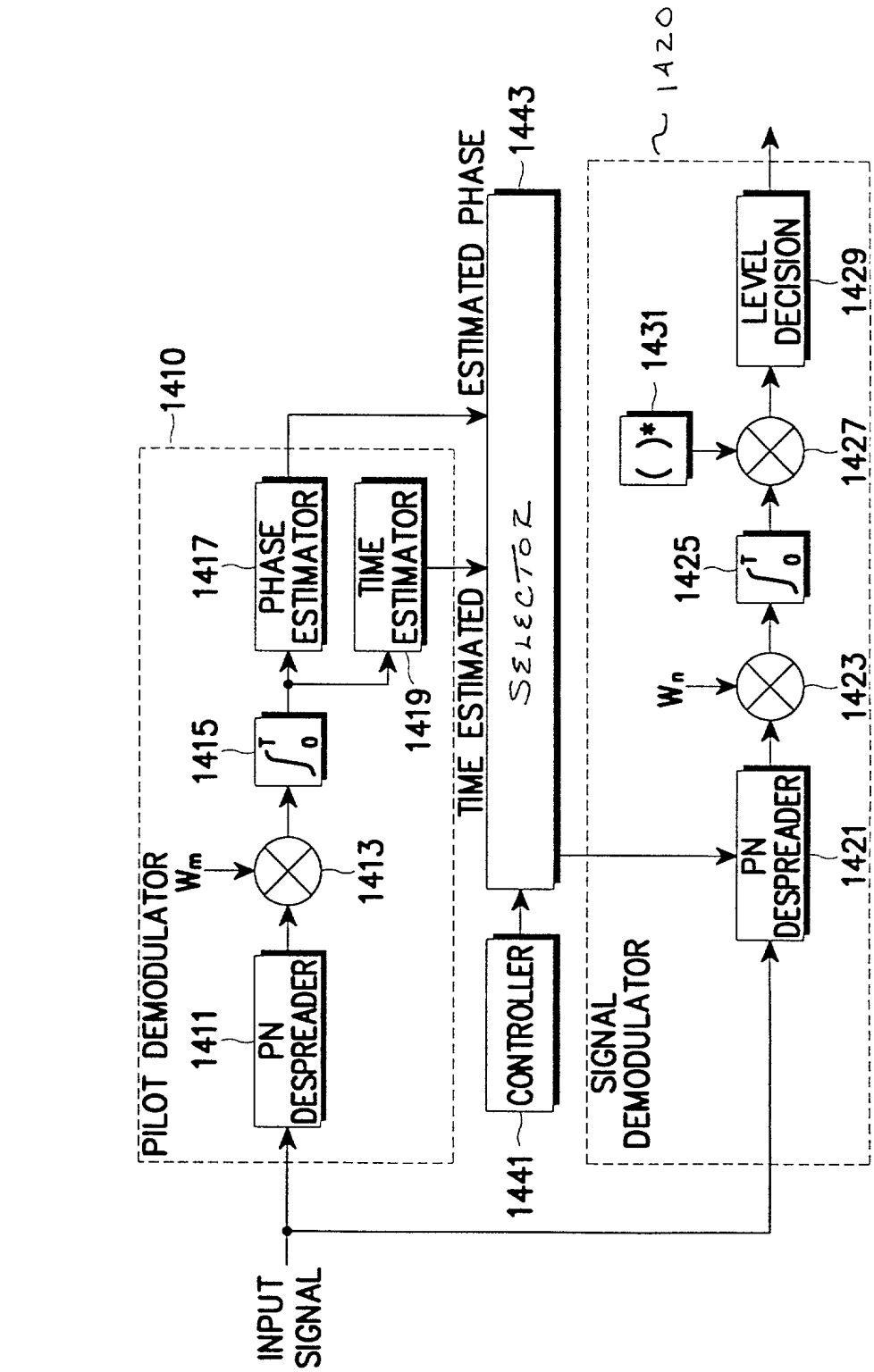
INPUT SIGNAL
PILOT DEMODULATOR
1410
PN DESPREADER
1411
W_m
1413
$\int_0^T$
1415
PHASE ESTIMATOR
1417
TIME ESTIMATOR
1419
CONTROLLER
1441
TIME ESTIMATED
ESTIMATED PHASE
1443
Selector
SIGNAL DEMODULATOR
1420
PN DESPREADER
1421
W_n
1423
$\int_0^T$
1425
( )*
1431
1427
LEVEL DECISION
1429

FIG. 14